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STUDY ON DETERMINATION OF COEFFICIENT OF MODULUS OF ELASTICITY FOR COCONUT SHELL CONCRETE

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ABSTRACT

In developing countries, the wide spread use of concrete increased its cost leading to a price hike in construction. This, combined with the disastrous effect of concrete production on the environment compelled studies on different alternatives that provide use as replacement for coarse aggregate. So study on substitute concrete materials produced using crushed, granular coarse aggregate for complete replacement of coconut shell is essential. Determining modulus of elasticity for coconut shell concrete is the main aim of the study. For structural analysis, the modulus of elasticity is one of the premium parameters. This is necessary for evaluating strain behavior and displacements, particularly when design depends on elasticity considerations. One of the important reasons has been proved that mechanical properties of concrete depend on the aggregate proportions and properties to the significant extent. M25 grade of Coconut shell concrete was attained by using 510 kg/m^3 of cement. Cylinder specimens were cast to determine the stress-strain characteristics. From the stress-strain characteristics and regression analysis of the experimental data, empirical equations have been formulated to predict coefficient of modulus of elasticity.

Key words: Alternative material; Coconut shell; Modulus of elasticity; Regression analysis; Stress-strain.

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1. INTRODUCTION

Infrastructure development created demand for construction materials all over the world due to increased population and urbanisation. Concrete is most widely used in all type of civil engineering works and premier structural material in the world today. Now there is a demand

to make the concrete material lighter for both scientists and engineers. The main aim of production of light weight concrete is substantially lowers the unit weight without any increase of cost.

For manufacturing of concrete mainly involves cement, river sand, crushed aggregate and water. Among all these materials aggregates which are inert form the major part. Previously aggregates are available at normal economic prices but now a days these prices are rising day by day because of scarcity of materials. This is mainly due to lack of natural resources. Then the utilisation of alternative materials which reduce self-weight is most important concern [1].Different alternative natural or artificial materials such as pumice, fly ash, coconut shell, rice husk ash, vermiculite, expanded clay, perlite can be used for the production of light weight concrete [2]

Apart from above mentioned materials, coconut shell is one such alternative . Coconut shell is well known and one of the most processing agro wastes with its accessible uses as coarse aggregate in concrete. India occupies the predominant position in the world with a yearly production of 13 billion nuts followed by Indonesia, Philippines. The shell of the coconut after scraped out is generally discarded and regarded as waste. Potential use of these shells will occur where coarse aggregates are costly [3]

The contemporary research was going on to access the suitability of coconut shell in concrete. It was studied that long term study on compressive and bond strength [4], mechanical and bond properties [5], durability properties [6] and flexural behaviour of CSC and CC was almost alike and within the range of CC[7]. The most essential mechanical parameter used in design, which quantifies the material ability to deform elastically is Elastic Modulus. This knowledge of modulus of elasticity for the designer is important in gauging the deformation of structural elements in reinforced concrete under service condition. In this research, the concrete of grade M25 with CC and CSC can be developed. Based on the characteristics of stress-strain, it is proposed to predict coefficient of modulus of elasticity for CSC.

2. MATERIALS USED &MIX DESIGN

The methodology adopted for experimental investigation is carried out by using these materials and presented as follows.

2.1. Cement

Ordinary Portland cement is one of the most extensively used with all types of Portland Cement. In this project OPC 53 grade is taken and cement must satisfy the requirement of IS: 12269-1987[8]. The initial setting time was found to be 30min having a specific gravity of 3.15.

2.2. Fine Aggregates

River Sand is used as a fine aggregate in this project has been sieved through 4.75mm confirmed to Zone 3 according to IS: 383-1970 [9]specification. Fine aggregate should completely free from organic, inorganic and biological matter. After testing physical properties the fineness modulus of sand, specific gravity is 2.59 and 2.7 respectively.

2.3. Coarse Aggregates

The materials are collected from nearby quarries and nominal 12mm size are used in concrete as per IS: 383-1970, these aggregates serve as reinforcement to add strength to over all composite material. The fineness modulus of coarse aggregates is 6.8 with a specific gravity of 2.73.

2.4. Water

Normal tap water is used for mixing the constituents of concrete throughout casting as well as curing confirming as per IS: 456-2000 [10].

2.5. Coconut Shell

Coconut shell finds use as complete replacement of coarse aggregate, passing through 12.5mm sieve for concrete production. These collected coconut shell must be well seasoned before using for research and crushed by crushing machine which was installed in SRM University. The specific gravity is found to be 1.14. Due to more absorption capacity of having 24%, these shells must be kept in saturated surface dry condition (SSD).

2.6. Mix Design

The aim of mix preparation is to select the ingredients, needed to gain the desired grade of concrete such that the mixture with appropriate ingredient content to attain good mechanical properties. For the manufacture of light weight coconut shell and conventional the mix design conforming to IS 10262:2009 [11]mainly depends upon physical properties. The chosen mix ratio for M25 grade from previously established studies. For Conventional concrete is 1:2.2:3.66:0.55 having a cement content 320kg/m^3 and Coconut shell concrete is 1:1.47:0.65:0.42 having a cement content 510kg/m$^{3.}$.

3. EXPERIMENTAL PROGRAM

During the course of research, cubical specimens of size (100 mm ×100 mm × 100 mm) for both Coconut shell and Conventional concrete has been cast to find compressive strength, density. Based on the trial mix design to obtain coefficient, a set of 40 cylinders were cast of size (100 mm diameter×200 mm height) for conventional as well as coconut shell. The average modulus of elasticity, chord modulus, coefficient of secant modulus for M25 is calculated for coconut shell. The cast cylindrical specimens are shown in Fig1.The stress verses strain curve is plotted by using compress meter and strain gauges.

Figure 1 After 28 days curing of CSC cylindrical specimens

4. EXPERIMENTAL RESULTS

4.1. Compressive Strength

After curing of 3, 7, 28 days the cubical specimens for CSC as well as CC are tested by using Compression testing machine having a maximum capacity of 20Tons to determine compressive strength as per IS 516:1959 [12]. The results obtained from experimental are shown in Table 1.

Table 1 Compressive strength results

S.No	Concrete type	Compressive strength f_{ck} (N/mm^2)			Unit weight (kg/m^3)		
		3 days	7 days	28 days	3 days	7 days	28 days
1	Conventional concrete	18.6	21.35	32.8	2595	2661	2625
2	Coconut shell concrete	18.93	22.1	26.1	1933	2003	2016

From the above results, the coconut shell concrete density varied from 1900kg/m^3 to 2000 kg/m^3 less, when compared to conventional and satisfies the requirement of light weight concrete

4.2. Stress-Strain Behaviour

Out of the total set of cylinders, half of the set was tested by using compressometer and remaining with strain gauges. Compressometer having dial gauge & strain gauges are shown in Fig:2, were employed for finding strain readings, displacements

Figure 2 Testing of cylindrical specimens (CC and CSC)

Modulus of Elasticity was determined according to ASTMC469 [13]. This method involves applying compressive load longitudinally to the concrete cylindrical specimen for calculating elastic modulus. During a compression test for measuring axial and lateral deformation, 4 strain gauges are attached to the specimen. Graphs of stress verses strain were plotted based on elongation readings in both cases and comparison was drawn for Coconut shell and Conventional concrete is displayed in Fig:3 & Fig:4.

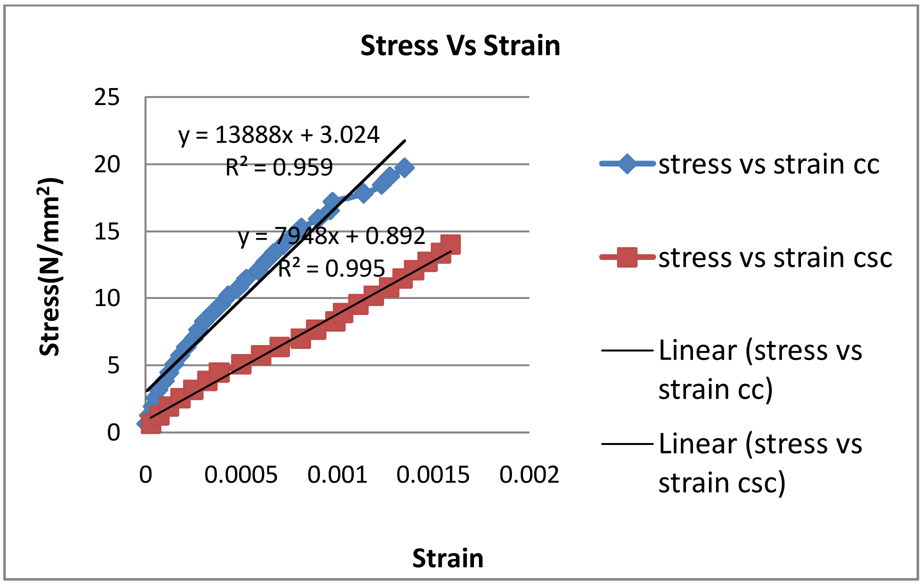

Figure 3 Stress vs strain by using compressomete

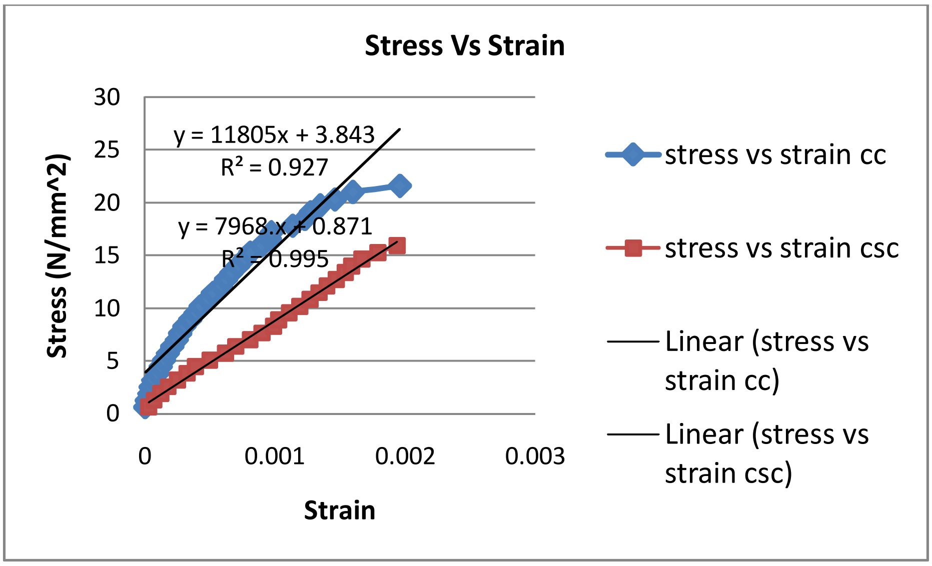

Figure 4 Stress vs strain by using strain gauges

From above graphs, stress-strain characteristics of CSC are not alike as CC but almost having a same parabolic path [14] As the consequence of higher elongation readings, the obtained strain value is more at failure leading to the lower value of modulus of elasticity compared to conventional as per IS:456:2000. The following results are shown in Table 2.

Table 2 Cylinder compressive strength& Strain at peak stress Results

Method	Type of concrete	Cylinder Compressive strength(MPa)	Strain at peak stress	Average modulus of elasticity(MPa)
Compressometer	Conventional	21.64	0.0016	26680
	Coconut shell	15	0.0015	10465
Strain Gauges	Conventional	22.03	0.0022	27787
	Coconut shell	16.2	0.00194	13300

Based on the tested results, the modulus of elasticity for CC is having a slight 1.5 to 5% less in variation when compared with $5000\sqrt{f_{ck}}$ as per IS456, where f_{ck} is characteristic cube strength.

4.3. Secant Modulus & Chord Modulus of Elasticity

Secant modulus is the gradient of a line from the origin to any point on a stress-strain curve. From results, it is observed that the ultimate peak load for Coconut shell is 40% less than CC.

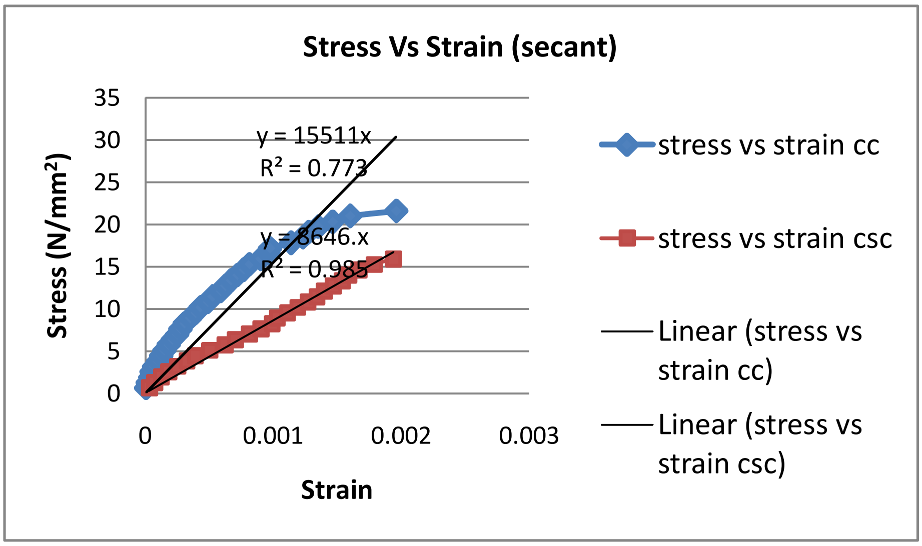

Figure 5 Stress vs strain by using strain gauges

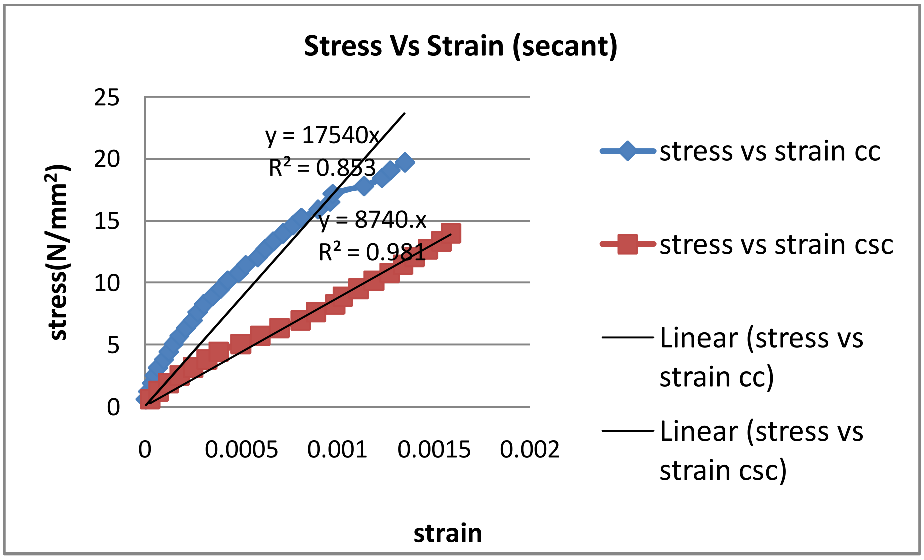

Figure 6 Stress vs strain by using compressometer

The following graphs for secant modulus by using strain gauge & compressometer are displayed in Fig:5 & Fig:6 respectively. The secant modulus for coconut shell concrete varies from 8.6GPa to 9GPa is very much lower than conventional as per IS456:2000. The curve with a steep slope (CC) has greater stiffness and the curve with the gentle slope is comparatively more flexible (CSC). The value of chord modulus is helpful in evaluating the difference in a strain for a given range in stress. The chord modulus was calculated by testing the samples to 40% of the ultimate concrete strength. The coefficient of secant modulus & chord modulus for M25 grade (CSC) is calculated based on regression analysis of the obtained data shown in Table 3.

Table 3 Coefficient values

Method used	Coefficient for secant modulus	Coefficient for modulus of elasticity	Chord Modulus (MPa)
Compressometer	1710	1558	9926
Strain gauges	1695	1559	8815

5. CONCLUSION

From this research, the stress-strain characteristics of CSC are studied, the following conclusions are obtained.

- CSC being a light weight has the greater difference in properties such as compressive strength, density, ultimate strain, elastic modulus. All of which are lower than conventional concrete. It is evident that CSC diminishes 1/2th of E-value.
- From experimental results the obtained modulus of elasticity for CC is nearly equal as per IS456:2000.
- For coconut shell, the maximum strain obtained at 0.002.
- Both by using compressometer and strain gauges, the coefficient obtained after regression analysis is almost same i.e. 1560 and for secant modulus 1702.
- The stiffness of CSC is also lesser. This does not a pose a problem, as the self-weight carried by the CSC concrete is not as much as CC consequently the overall effects tends to be a minute reduction in slab depth or beam.

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